Effects of alfalfa hay and its physical form (chopped versus pelleted) on performance of Holstein calves

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ABSTRACT

Inclusion of forage and its physical form in starter may affect rumen development, average daily gain (ADG), and dry matter intake (DMI) of dairy calves. To evaluate the effects of forage and its physical form (chopped vs. pelleted) on growth of calves under a high milk feeding regimen, 32 Holstein calves (38.8 ± 1.1 kg) were assigned at birth to 1 of 3 treatments in a completely randomized block design. Dietary treatments (% of dry matter) were (1) 100% semi-texturized starter (CON); (2) 90% semi-texturized starter + 10% chopped alfalfa hay (mean particle size = 5.4 mm) as a total mixed ration (TMR; CH); and (3) 90% semi-texturized starter + 10% pelleted alfalfa (mean = 5.8 mm) hay as a TMR (PH). Data were subjected to mixed model analysis with contrasts used to evaluate effect of forage inclusion. Calves were weaned at 76 d of age and the experiment finished 2 wk after weaning. Individual milk and solid feed consumption were recorded daily. Solid feed consumption and ADG increased as age increased (effect of week), but neither forage inclusion nor physical form of forage affected these variables pre- or postweaning. Plasma urea N was affected by treatments such that the CON group had a lower concentration than forage-fed groups. Forage inclusion, but not physical form, resulted in increased total protein in plasma. Although days with elevated rectal temperature, fecal score, and general appearance were not affected by dietary treatments, calves fed alfalfa hay during the first month of life had fewer days with respiratory issues, regardless of physical form of hay. We concluded that provision of forage does have some beneficial effects in calves fed large amounts of milk replacer, but pelleted alfalfa hay did not result in any improvement in calf performance or health.

Key words: calf, forage, growth, weaning

INTRODUCTION

Having healthy calves is vital for profitable dairy farming, and the long-term effects of preweaning management on potential milk yield during first and subsequent lactations have been reviewed (Soberon et al., 2012; Soberon and Van Amburgh, 2013). Traditionally, in an attempt to accelerate weaning, reduce the potential for scours, and decrease the cost of feeding and management, weaning strategies have aimed to restrict the amount of milk or milk replacer offered to the calf to encourage early grain consumption (Kertz et al., 1979). In recent years, researchers have reported the effects of solid form (texturized and mesh forms) of diet during the preweaning period (Khan et al., 2011; Castells et al., 2012, 2013). Forage feeding during the preweaning period has been discouraged because of the limited digestibility of cellulose and accumulation of forage in the rumen, which in turn can decrease starter intake (Drackley, 2008). According to NRC (2001), calf starter should be relatively high in easily fermentable carbohydrates to support the fermentation needed for proper ruminal tissue growth. However, feeding concentrate that is high in rapidly fermentable carbohydrates can also decrease ruminal pH (Beharka et al., 1998) and may cause overgrowth and keratinization of ruminal papillae (Bull et al., 1965), decreasing absorption of VFA in the rumen (Hinders and Owen, 1965).

A growing body of recent literature supports inclusion of forage in the diet during the preweaning period (Khan et al., 2011; Castells et al., 2012, 2013; Montoro et al., 2013). Castells et al. (2012) showed that, with the exception of alfalfa hay, offering chopped grass hay or grass silages to young dairy calves during the pre- and postweaning periods separately from the starter feed resulted in calves consuming a small amount of forage but also resulted in an increase in concentrate intake and improved ADG. In a subsequent study (Castells et al., 2013), the same group did not observe any difference between alfalfa and chopped grass hay that had been supplemented. In addition to forage content of the ration, particle size also influences the ruminal

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environment, VFA production, and papillae structure (Montoro et al., 2013). Montoro et al. (2013) found that providing chopped grass hay compared with finely ground hay to young calves improved feed intake during the week after weaning. However, those authors did not use a concentrate treatment for comparison. In addition, it is not clear if the physical form (chopped vs. pelleted) of hay can affect preweaning performance.

Given the uncertainties remaining about inclusion of hay in diets and the effect of physical form of hay, the objectives of this study were to evaluate the effects of forage (alfalfa hay) and its physical form (chopped vs. pelleted) included in a TMR on calf performance pre- and postweaning.

MATERIALS AND METHODS

This experiment was conducted from March to June 2012 in a commercial dairy farm (Talise-Asil-e-Jahan, Varamin, Iran). Thirty-six (21 male and 15 female) Holstein calves aged 3 d with an average BW of 38.8 ± 1.1 kg were enrolled in the experiment and randomly assigned to treatments. Calves received colostrum (at least 4 L within the first 12 h of life) and were housed in individual stalls bedded with straw. Treatments (DM basis; Table 1) were (1) a semi-texturized starter without alfalfa (**CON**); (2) 90% CON + 10% chopped alfalfa (mean particle size = 5.4 mm; **CH**); and (3) 90% CON + 10% pelleted alfalfa (5.8 mm; **PH**). The diets were fed through weaning at d 76 of age (because of the farm's policy). After weaning, all calves were fed 80% CON + 10% chopped alfalfa hay and 10% pelleted alfalfa. Three male calves (2 because of subluxation and 1 because of hoof lesion) and 1 female calf (general weakness) were removed from the study because of health issues. Four male and 7 female calves remained in the CON and CH groups, whereas 4 males and 6 female calves remained in the PH group. Calves received milk replacer twice daily at 0700 and 1700 h. According to the farm's protocol, all calves were fed 6 L/d (12.5% DM) of a 22% CP (whey) and 19.5% fat milk replacer (**MR**; Spezial Neu, Josera GmbH & Co., Kleinheubach, Germany) until 10 d of age; 8 L/d from d 11 to 30; 10 L/d from d 31 to 50; 4 L/d from d 51 to 65; and 2 L/d from d 66 to 75 (only at the morning feeding).

Health criteria of the calves were monitored daily. The procedure described by Heinrichs et al. (2003) was used for fecal scoring (1 = normal; 2 = soft to loose; 3 = loose to watery; 4 = watery, mucous, and slightly bloody; and 5 = watery, mucous, and bloody), respiratory scoring (1 = normal; 2 = slight cough; 3 = moderate cough; 4 = moderate to severe cough; and 5 = severe and chronic cough), and general appearance scoring (1 = normal and alert; 2 = ears drooped; 3 =

head and ears drooped, dull eyes, slightly lethargic; 4 = head and ears drooped, dull eyes, lethargic; and 5 = severely lethargic). Rectal temperature was measured daily 3 h after the morning feeding. Body weight was recorded weekly before the morning feeding, and ADG was calculated as the difference between BW taken 1 wk apart divided by 7.

Blood samples were collected 1 h before the morning feeding on d 25, 50, and 75 for later analysis of glucose, albumin, total protein, urea N, triglyceride, and cholesterol using commercial kits (Pars Azmun Laboratory, Tehran, Iran). Blood was centrifuged at $3,000 \times g$ for 15 min at room temperature, and plasma was harvested and frozen at -20°C until analysis. Total globulin in plasma was calculated as the difference between total protein and albumin.

Data for DMI, ADG, health criteria, and rectal temperature were summarized for each calf by week. All data were analyzed with a mixed effects model (PROC MIXED, SAS version 9.1; SAS Institute Inc., Cary NC) for repeated measures. The final statistical model

Table 1. Ingredients (% of DM) and chemical composition of diet (DM basis)¹

Item	Treatment ²		
	CON	CH	PH
Chopped alfalfa	0.00	10.00	0.00
Pelleted alfalfa	0.00	0.00	10.00
Mash part of starter			
Steam-flaked corn ³	25.00	22.50	22.50
Steam-flaked barley ⁴	21.00	18.90	18.90
Beet pulp	3.00	2.70	2.70
Fragmented date	3.00	2.70	2.70
Pelleted part of starter			
Ground corn grain ⁵	7.00	6.30	6.30
Wheat bran	4.33	3.90	3.90
Full-fat soybean	0.48	0.43	0.43
Soybean meal	21.02	18.92	18.92
Corn gluten meal	3.00	2.70	2.70
Molasses	2.00	1.80	1.80
Wheat germ	8.00	7.20	7.20
Calcium carbonate	1.50	1.35	1.35
Salt	0.19	0.17	0.17
Mineral-vitamin premix	0.48	0.43	0.43
Chemical composition			
ME (Mcal/kg)	2.75	2.67	2.68
CP (% of DM)	20.3	19.8	20.0
Crude fat (% of DM)	4.2	3.9	4.0
NDF (% of DM)	16.0	18.8	18.2
ADF (% of DM)	7.4	9.9	9.3
NFC	55.0	49.8	50.0
Ash	5.60	5.46	5.46

¹Starter contained the mash (52% of DM) as well as pelleted (48% of DM) parts, with compositions as shown in the table.

²CON = starter without alfalfa (CON); CH = 90% CON + 10% chopped alfalfa; PH = 90% CON + 10% pelleted alfalfa.

³Flake density = ~ 290 g/L.

⁴Flake density = ~ 320 g/L.

⁵Size of 650 to 700 μm .

included the fixed effects of treatment, week, and sex, week $\times$ treatment interaction, and the random effect of calf within treatment. Differences among treatments were assessed using orthogonal contrast statements of effect of forage inclusion (CON vs. CH and PH) and physical form of forage (CH vs. PH).

Rectal temperature was categorized as number of days with temperature $\geq 40^\circ\text{C}$; fecal score (1 to 5 scale) was categorized as number of days with fecal score ≥ 2 ; respiratory score (1 to 5) was categorized as number of days with respiratory score ≥ 2 ; and general appearance (1 to 5) was categorized as number of days with general appearance score ≥ 2 . A multivariable logistic mixed model (PROC GLIMMIX, SAS version 9.1; SAS Institute Inc.) was used for the aforementioned variables. Fecal score was square-root transformed, and general appearance was log-transformed for better homogeneity of the distribution of residuals (means shown in Table 5 for these variables are back-transformed). Data are reported as least squares means and were considered significant if $P < 0.05$. Differences of $P < 0.10$ are discussed as trends.

RESULTS AND DISCUSSION

Although considerable research has been conducted on solid feed properties in calf nutrition, much remains uncertain concerning forage inclusion and physical form of the solid feed. The traditional recommendation is that 10 to 25% inclusion of chopped hay to a starter feed may result in increased DMI and ADG (Thomas and Hinks, 1982; Davis and Drackley, 1998). However, Castells et al. (2012) showed that calves choose a proportion between 4 and 8% of chopped forage (rye-grass hay, oat hay, barley straw, triticale silage, and corn silage) when forage and starter feed are offered separately. Because we fed a TMR, we chose the lowest level of traditional recommendations for forage, which was close to the upper limit reported by Castells et al. (2012).

Intakes and performance data are reported in Table 2. Calf BW were similar at the start of the experiment. Dietary treatments did not influence preweaning or final BW. No treatment differences were observed in MR consumption, solid feed intake, or total DMI. Regardless of dietary treatment, provision of the high amount of MR along with an underdeveloped rumen during wk 1 to 7 likely precluded any effect of treatments on solid feed intake during this period. Because of similar ADG and DMI, the gain-to-feed ratio was not affected by treatments. In agreement with previous reports (Appleby et al., 2001; Khan et al., 2011), solid feed consumption was very low during the first month

of life, regardless of treatment diet, which is known to reflect the greater amount of milk or MR fed within the first month of life. As expected, the effect of week was significant for both intake and BW parameters because solid feed consumption and ADG increased as the experiment progressed.

Neither forage inclusion nor forage physical form affected total DMI (Table 2). In contrast to our results, Terré et al. (2013) observed greater total DMI from wk 5 of the study and thereafter, probably due to the method of forage supplementation; they offered chopped hay separately from starter. Suárez et al. (2007) also did not observe differences in total DMI when part of the starter feed was substituted by roughage during the preweaning period. In contrast to the current study, Coverdale et al. (2004) reported that the addition of hay to diets appeared to favorably alter the rumen environment (e.g., rumen pH), resulting in increased intake and improved efficiency. Moreover, Castells et al. (2012) reported that dietary inclusion of chopped grass hay improved total DMI in young calves. Part of the discrepancy between our results and others might be due to the structure of the starter (semi-texturized vs. crumb), forage supplementation as a part of a TMR, and the amount of milk offered. For example, Castells et al. (2012) fed calves with different sources of forages separately from the starter. They concluded that with the exception of alfalfa, forage provision increased total DMI (starter plus forage). Almost all of experiments reporting favorable results of forage inclusion (Khan et al., 2011; Montoro et al., 2013) have attributed this improvement to an improved rumen pH and environment. However, the lack of differences among treatments in our study may indicate that rumen characteristics were not dramatically modified by hay supplementation. Lack of responses for preweaning performance are in agreement with observations by Terré et al. (2013), who did not observe any effect of forage on preweaning ADG even though DMI was increased in forage-supplemented calves. Although the results of Montoro et al. (2013) favored long versus short chopped hay (as an investigated physical form of forage), their study lacked a starter treatment without forage, making it difficult to compare their results with ours. They also used a crumbled starter, whereas we fed a semi-texturized starter, which could affect results. Kertz (2011) stated that inclusion of hay in a "texturized" calf starter appears to have some marginal benefits. That statement should be interpreted with caution, however, because not all texturized calf starters are equal. For example, Khan et al. (2011) fed a texturized starter but the rumen pH results showed it was not well texturized. The simplest way to make a texturized starter is to have

Table 2. Performance and feed intake of calves supplemented with starter and different forms of alfalfa during pre- and postweaning

Item	Treatment ¹				P-value ²			Contrast P-value	
	CON	CH	PH	SEM	T	W	T × W	Starter vs. hay	CH vs. PH
Birth BW (kg)	38.9	38.7	39.7	1.81	0.47	—	—	0.25	0.58
Weaning BW (kg)	84.1	80.6	83.3	3.28	0.71	—	—	0.58	0.56
Final BW (kg)	98.4	96.6	97.8	3.35	0.92	—	—	0.76	0.80
Weeks 1–4									
Solid feed intake (kg/d)	0.10	0.10	0.14	0.02	0.46	<0.01	0.65	0.50	0.28
Milk intake (L/d)	7.11	7.20	7.16	0.07	0.61	<0.01	0.33	0.42	0.62
Total DMI (kg/d)	0.99	1.00	1.03	0.02	0.44	<0.01	0.53	0.35	0.36
ADG (kg/d)	0.27	0.27	0.27	0.04	0.99	<0.01	0.77	0.97	0.90
Gain to feed	0.24	0.26	0.20	0.05	0.72	<0.01	0.78	0.89	0.43
Weeks 5–7									
Solid feed intake (kg/d)	0.24	0.25	0.27	0.04	0.88	<0.01	0.79	0.66	0.77
Milk intake (L/d)	9.67	9.61	9.65	0.08	0.85	<0.01	0.44	0.69	0.70
Total DMI (kg/d)	1.45	1.46	1.48	0.04	0.90	<0.01	0.61	0.74	0.72
ADG (kg/d)	0.84	0.81	0.80	0.04	0.84	0.35	0.92	0.56	0.91
Gain to feed	0.58	0.55	0.54	0.03	0.57	0.94	0.89	0.31	0.79
Weeks 8–11									
Solid feed intake (kg/d)	1.26	1.34	1.29	0.11	0.89	<0.01	0.17	0.72	0.78
Milk intake (L/d)	3.35	3.36	3.36	0.00	0.43	<0.01	0.50	0.20	0.98
Total DMI (kg/d)	1.68	1.76	1.71	0.11	0.89	<0.01	0.17	0.72	0.78
ADG (kg/d)	0.83	0.79	0.81	0.06	0.90	<0.01	0.59	0.69	0.83
Gain to feed	0.52	0.46	0.50	0.04	0.59	0.44	0.93	0.43	0.53
Total preweaning									
Solid feed intake (kg/d)	0.56	0.59	0.59	0.07	0.93	<0.01	0.12	0.71	0.99
Milk intake (L/d)	6.44	6.46	6.45	0.03	0.91	<0.01	0.46	0.67	0.93
Total DMI (kg/d)	1.37	1.40	1.40	0.06	0.92	<0.01	0.13	0.68	0.99
ADG (kg/d)	0.63	0.61	0.61	0.04	0.90	<0.01	0.98	0.64	0.96
Gain to feed	0.43	0.41	0.40	0.02	0.61	<0.01	0.98	0.34	0.79
Postweaning									
Solid feed intake (kg/d)	2.62	3.23	3.03	0.29	0.30	<0.01	0.54	0.15	0.64
ADG (kg/d)	0.95	0.98	1.06	0.11	0.79	0.44	0.58	0.63	0.63
Gain to feed	0.37	0.35	0.36	0.04	0.94	0.28	0.57	0.82	0.81
Total ADG (kg/d)	0.68	0.66	0.68	0.03	0.92	<0.01	0.99	0.82	0.74
Total solid feed intake (kg/d)	1.55	1.67	1.64	0.12	0.78	<0.01	0.68	0.50	0.88
Gain to feed	0.42	0.40	0.40	0.02	0.61	<0.01	0.99	0.32	0.97

¹CON = starter without alfalfa (CON); CH = 90% CON + 10% chopped alfalfa; PH = 90% CON + 10% pelleted alfalfa.

²T = treatment effect; W = week effect; T × W = treatment by week interaction.

at least 40 to 45% whole shelled corn (Alois F. Kertz, ANDHIL LLC, St. Louis, MO; personal communication).

During the postweaning period, from wk 12 to 13 of the study, calves previously supplemented with forage had similar DMI and ADG ($P > 0.05$) to calves not already fed forage. As a result, the gain-to-feed ratio was similar across treatments. Several researchers (Coverdale et al., 2004; Khan et al., 2011; Terré et al., 2013) have reported higher postweaning DMI in hay-supplemented calves, in contrast with the current study, likely because of the longer preweaning period and more mature rumen in all calves in the current study. Despite the higher postweaning DMI, Coverdale et al. (2004) observed no difference in ADG. Greater postweaning ADG in the aforementioned studies with hay supplementation has been attributed to higher DMI and the gut-filling effect of forage. Although we did not measure abnormal behaviors, such as oral behaviors

(such as licking any surface, tongue rolling, or consuming wood shavings) and head butting (when the animal pressed any surface with its head), some researchers (Castells et al., 2012; Terré et al., 2013) showed a lower frequency of such behaviors in forage-supplemented calves. Economically, inclusion of hay decreased the cost of the ration and yielded similar performance efficiency in the current experiment. These results would promote forage inclusion during preweaning period.

Concentrations of glucose, urea N, total protein, albumin, triglyceride, and cholesterol in calves are presented in Table 3. Other than urea N and total protein, metabolites were not affected by dietary treatments ($P > 0.10$). The general decrease in glucose and increase in urea N as the experiment progressed are attributed to development of ruminal function, which was likely similar among treatments, as shown by others (Khan et al., 2007). Given that urea N stems from ruminal ammonia or deamination of AA in the liver, higher urea N in

Table 3. Blood variables of calves supplemented with starter and different forms of alfalfa during the preweaning period

Item	Treatment ¹				P-value ²			Contrast P-value	
	CON	CH	PH	SEM	T	W	T × W	Starter vs. hay	CH vs. PH
Glucose (mg/dL)									
d 25	78.6	81.3	85.1	4.89	0.65	—	—	0.44	0.59
d 50	96.0	94.3	91.6	5.35	0.85	—	—	0.65	0.73
d 75	75.5	69.2	79.8	5.65	0.41	—	—	0.89	0.19
Total	83.3	81.6	85.5	2.98	0.65	<0.01	0.72	0.95	0.36
Urea N (mg/dL)									
d 25	12.65	12.95	12.53	0.30	0.59	—	—	0.81	0.33
d 50	11.75	12.72	13.32	0.49	0.09	—	—	0.04	0.39
d 75	13.85	15.19	15.08	0.46	0.08	—	—	0.03	0.86
Total	12.75	13.62	13.65	0.27	0.05	<0.01	0.20	<0.01	0.95
Total protein (g/dL)									
d 25	5.69	5.73	5.66	0.13	0.91	—	—	0.97	0.67
d 50	5.43	5.65	5.60	0.13	0.47	—	—	0.23	0.78
d 75	5.62	6.10	5.96	0.17	0.15	—	—	0.06	0.62
Total	5.58	5.83	5.74	0.11	0.29	<0.01	0.51	0.14	0.59
Albumin (g/dL)									
d 25	3.08	3.12	3.20	0.06	0.31	—	—	0.26	0.29
d 50	3.16	3.15	3.18	0.07	0.96	—	—	0.95	0.78
d 75	3.27	3.37	3.48	0.13	0.55	—	—	0.34	0.57
Total	3.17	3.21	3.29	0.07	0.48	<0.01	0.81	0.34	0.44
Globulin									
d 25	2.61	2.62	2.45	0.11	0.49	—	—	0.58	0.29
d 50	2.27	2.50	2.42	0.10	0.26	—	—	0.13	0.55
d 75	2.34	2.72	2.48	0.12	0.11	—	—	0.10	0.20
Total	2.41	2.61	2.45	0.08	0.15	0.14	0.36	0.20	0.15
Triglyceride (mg/dL)									
d 25	29.55	27.73	26.34	2.30	0.62	—	—	0.37	0.67
d 50	22.21	25.30	19.15	2.01	0.12	—	—	0.99	0.04
d 75	31.73	33.00	34.77	4.32	0.88	—	—	0.68	0.77
Total	27.82	28.67	26.74	2.10	0.81	<0.01	0.64	0.97	0.52
Cholesterol (mg/dL)									
d 25	99.5	97.6	96.7	6.62	0.96	—	—	0.77	0.92
d 50	107.5	89.4	94.7	7.64	0.23	—	—	0.10	0.63
d 75	80.1	82.2	82.3	5.80	0.95	—	—	0.76	0.98
Total	95.8	89.8	91.3	5.20	0.69	<0.01	0.16	0.41	0.84

¹CON = starter without alfalfa (CON); CH = 90% CON + 10% chopped alfalfa; PH = 90% CON + 10% pelleted alfalfa.

²T = treatment effect; W = week effect; T × W = treatment by week interaction.

forage-supplemented calves might be because of lower supply of ruminal energy (starch) to incorporate N into rumen microorganisms for microbial protein (NRC, 2001). Henning et al. (1991) showed that the fastest rate of energy availability gave the highest bacterial cell production efficiency.

Total protein was increased by forage inclusion (Table 3). Although we found no difference in albumin concentration among calves, plasma globulin concentrations tended to be higher at d 75 for CON compared with CH and PH. Some studies have shown that with advancing age and development in calf, total protein and globulin (especially gamma globulin) concentrations increase (Ježek et al., 2006; Mohri et al., 2007; Kaneko et al., 2008). Provision of forage, particularly chopped alfalfa, might have improved physical development of the reticulorumen in calves (Khan et al., 2011), increased digestive capacity (de Passillé et al., 1992), and, consequently, improved immune status.

Cholesterol tended to be lower at d 50 for forage-supplemented calves, but triglyceride concentrations were lower in PH than in CH calves ($P < 0.04$) at d 50. Decreased cholesterol concentrations may be due in part to the ability of fiber to inhibit lipid absorption from the gut and increase bile acid synthesis (Story, 1981). Endogenously synthesized cholesterol is the preferred substrate for bile acid synthesis (Staple and Gurin, 1954; Balasubramaniam et al., 1973), which would result in decreased blood cholesterol concentrations. In addition, our earlier findings (Mahjoubi et al., 2009) in lactating dairy cows showed that replacing barley grain with beet pulp decreased plasma cholesterol concentration. No clear explanation exists for the lower triglyceride concentration in calves fed PH than in those fed CH.

Respiratory score, rectal temperature, and general appearance score are given in Table 4. Because of the nature of these categorical data, ANOVA approaches

Table 4. Mean values for health criteria and body rectal temperature (°C) of calves supplemented with starter and different forms of alfalfa during the preweaning period

Item	Treatment ¹				P-value ²			Contrast P-value	
	CON	CH	PH	SEM	T	W	T × W	Starter vs. hay	CH vs. PH
Week 1–4									
Rectal temperature	38.82	38.86	38.86	0.06	0.88	0.49	0.06	0.62	0.99
Fecal score ³	1.30	1.27	1.30	0.06	0.87	<0.01	0.61	0.77	0.68
Respiratory score ⁴	1.11	1.04	1.02	0.02	<0.01	0.03	0.93	<0.01	0.62
General appearance ⁵	1.13	1.12	1.13	0.04	0.97	0.88	0.46	0.86	0.90
Week 5–7									
Rectal temperature	38.80	38.92	38.84	0.04	0.18	<0.01	<0.01	0.16	0.26
Fecal score	1.09	1.11	1.09	0.03	0.82	0.19	0.55	0.81	0.57
Respiratory score	1.21	1.12	1.14	0.05	0.34	0.17	0.07	0.16	0.78
General appearance	1.07	1.10	1.09	0.04	0.75	0.24	0.18	0.47	0.86
Week 8–11									
Rectal temperature	38.85	38.83	38.86	0.04	0.90	0.01	0.54	0.94	0.66
Fecal score	1.06	1.04	1.02	0.02	0.44	0.40	0.04	0.25	0.53
Respiratory score	1.04	1.03	1.01	0.01	0.24	0.09	0.59	0.15	0.33
General appearance	1.05	1.04	1.03	0.02	0.65	0.98	0.08	0.37	0.85

¹CON = starter without alfalfa (CON); CH = 90% CON + 10% chopped alfalfa; PH = 90% CON + 10% pelleted alfalfa.

²T = treatment effect; W = week effect; T × W = treatment by week interaction.

³Where 1 = normal; 2 = soft to loose; 3 = loose to watery; 4 = watery, mucous, and slightly bloody; and 5 = watery, mucous, and bloody.

⁴Where 1 = normal; 2 = slight cough; 3 = moderate cough; 4 = moderate to severe cough; and 5 = severe and chronic cough.

⁵Where 1 = normal and alert; 2 = ears drooped; 3 = head and ears drooped, dull eyes, slightly lethargic; 4 = head and ears drooped, dull eyes, lethargic; and 5 = severely lethargic.

Table 5. Days experiencing a health criterion or elevated rectal temperature of calves supplemented with starter and different forms of alfalfa during the preweaning period

Item	Treatment ¹				P-value ²		Contrast P-value	
	CON	CH	PH	SEM	T		CON vs. CH and PH	
Weeks 1–4								
Rectal temperature ³	0.09	0.18	0.22	0.14	0.81		0.53	
Fecal score ⁴	5.36	5.00	5.22	0.84	0.91		0.83	
Respiratory score ⁵	2.54	0.90	0.77	0.34	<0.01		<0.01	
General appearance ⁶	1.13	1.12	1.20	0.04	0.60		0.48	
Weeks 5–7								
Rectal temperature	0.27	0.36	0.11	0.17	0.63		0.87	
Fecal score	1.63	1.81	1.89	0.45	0.55		0.36	
Respiratory score	3.27	2.00	2.33	0.62	0.76		0.50	
General appearance	0.90	1.54	1.33	0.43	0.19		0.62	
Weeks 8–11								
Rectal temperature	0.63	0.18	0.66	0.23	0.27		0.46	
Fecal score	0.90	0.81	0.55	0.29	0.75		0.93	
Respiratory score	0.90	0.45	0.22	0.24	0.70		0.80	
General appearance	1.00	0.72	0.55	0.35	0.96		0.80	

¹CON = starter without alfalfa (CON); CH = 90% CON + 10% chopped alfalfa; PH = 90% CON + 10% pelleted alfalfa.

²T = treatment effect.

³Days with temperature $\geq 40^{\circ}\text{C}$.

⁴Days with fecal score ≥ 2 (where fecal score 1 = normal; 2 = soft to loose; 3 = loose to watery; 4 = watery, mucous, and slightly bloody; and 5 = watery, mucous, and bloody); fecal score was square-root transformed.

⁵Days with respiratory score ≥ 2 (where respiratory score 1 = normal; 2 = slight cough; 3 = moderate cough; 4 = moderate to severe cough; and 5 = severe and chronic cough).

⁶Days with general appearance score ≥ 2 (where general appearance 1 = normal and alert; 2 = ears drooped; 3 = head and ears drooped, dull eyes, slightly lethargic; 4 = head and ears drooped, dull eyes, lethargic; and 5 = severely lethargic). General appearance was log-transformed, and back-transformed values are presented in the table.

are not appropriate but results are shown here for general comparison among groups. Logistic models categorizing frequency of events are more valid, but insufficient calves were available in all classifications to conduct the regressions by week.

Days with increased respiratory score were higher ($P < 0.01$) for calves fed CON during the first month of life (Table 5). The reason for this small difference in respiratory score is not clear. A possible reason might be related to lowered abnormal behaviors when supplementing forage, which has been reported by others (Castells et al., 2012; Terré et al., 2013). The number of days with elevated temperature or fecal score, or with altered general appearance score, did not differ among treatments at any stage.

In conclusion, under high levels of milk feeding, forage supplementation had little effect on intake, ADG, or efficiency. Pelleting hay produced no benefit over chopping hay. Small changes in blood variables indicated that there were alterations in rumen or systemic metabolism that were positive or neutral to calves. More experiments are needed to address rumen function and development when feeding such diets.

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REFERENCES

- Appleby, M. C., D. M. Weary, and B. Chua. 2001. Performance and feeding behavior of calves on ad libitum milk from artificial teats. *Appl. Anim. Behav. Sci.* 74:191–201.
- Balasubramaniam, M., A. Itropoulosk, and N. B. Myant. 1973. Evidence for the compartmentation of cholesterol in rat liver microsomes. *Eur. J. Biochem.* 34:77–83.
- Beharka, A. A., T. G. Nagaraja, J. L. Morrill, G. A. Kennedy, and R. D. Klemm. 1998. Effects of form of the diet on anatomical, microbial, and fermentative development of the rumen of neonatal calves. *J. Dairy Sci.* 81:1946–1955.
- Bull, L. S., L. J. Busch, J. D. Friend, B. Harris Jr., and E. W. Jones. 1965. Incidence of ruminal parakeratosis in calves fed different rations and its relation to volatile fatty acids absorption. *J. Dairy Sci.* 48:1459–1466.
- Castells, L., A. Bach, G. Araujo, C. Montoro, and M. Terré. 2012. Effect of different forage sources on performance and feeding behavior of Holstein calves. *J. Dairy Sci.* 95:286–293.
- Castells, L., A. Bach, A. Aris, and M. Terré. 2013. Effects of forage provision to young calves on rumen fermentation and development of the gastrointestinal tract. *J. Dairy Sci.* 96:5226–5236.
- Coverdale, J. A., H. D. Tyler, J. D. Quigley III, and J. A. Brumm. 2004. Effect of various levels of forage and form of diet on rumen development and growth in calves. *J. Dairy Sci.* 87:2554–2562.
- Davis, C. L., and J. K. Drackley. 1998. *The Development, Nutrition and Management of the Young Calf*. Iowa State University Press, Ames, IA.
- de Passillé, A. M. B., J. H. M. Metz, and P. R. Wiekema. 1992. Does drinking milk stimulate sucking in young calves? *Appl. Anim. Behav. Sci.* 34:23–36.
- Drackley, J. K. 2008. Calf nutrition from birth to breeding. *Vet. Clin. North Am. Food Anim. Pract.* 24:55–86.
- Heinrichs, A. J., C. M. Jones, L. R. VanRoekel, and M. A. Fowler. 2003. Calf Track: A system of dairy calf workforce management, training, and evaluation and health evaluation. *J. Dairy Sci.* 86(Suppl. 1):115. (Abstr.)
- Henning, P. H., D. G. Steyn, and H. H. Meissner. 1991. The effect of energy and nitrogen supply pattern on rumen bacterial growth in vitro. *Anim. Prod.* 53:165–175.
- Hinders, R. G., and F. G. Owen. 1965. Relation of ruminal parakeratosis development to volatile fatty acid absorption. *J. Dairy Sci.* 48:1069–1073.
- Ježek, J., M. Klopčič, and M. Klinkon. 2006. Influence of age on biochemical parameters in calves. *Bull. Vet. Inst. Pulawy.* 50:211–214.
- Kaneko, J. J., J. W. Harvey, and M. L. Bruss. 2008. *Clinical Biochemistry of Domestic Animals*. 6th ed. Elsevier Academic Press, London, UK.
- Kertz, A. F. 2011. Adding forage to calf starters scrutinized. *Feed-stuffs* 83:12–13.
- Kertz, A. F., L. R. Prewitt, and J. P. Everett Jr. 1979. An early weaning calf program: Summarization and review. *J. Dairy Sci.* 62:1835–1843.
- Khan, M. A., H. J. Lee, W. S. Lee, H. S. Kim, S. B. Kim, K. S. Ki, J. K. Ha, H. G. Lee, and Y. J. Choi. 2007. Pre- and postweaning performance of Holstein female calves fed milk through step-down and conventional methods. *J. Dairy Sci.* 90:876–885.
- Khan, M. A., D. M. Weary, and M. A. G. von Keyserlingk. 2011. Hay intake improves performance and rumen development of calves fed higher quantities of milk. *J. Dairy Sci.* 94:3547–3553.
- Mahjoubi, E., H. Amanlou, D. Zahmatkesh, M. Ghelich Khan, and N. Aghaziarati. 2009. Use of beet pulp as a replacement for barley grain to manage body condition score in over-conditioned late lactation cows. *J. Anim. Feed Sci. Technol.* 153:60–67.
- Mohri, M., K. Sharifi, and S. Eidi. 2007. Hematology and serum biochemistry of Holstein dairy calves: age related changes and comparison with blood composition in adults. *Res. Vet. Sci.* 83:30–39.
- Montoro, C., E. Miller-Cushon, T. J. DeVries, and A. Bach. 2013. Effect of physical form of forage on performance, feeding behavior, and digestibility of Holstein calves. *J. Dairy Sci.* 96:1117–1124.
- NRC. 2001. *Nutrient Requirements of Dairy Cattle*. 7th rev. ed. Natl. Acad. Sci., Washington, DC.
- Soberon, F., E. Raffrenato, R. W. Everett, and M. E. Van Amburgh. 2012. Preweaning milk replacer intake and effects on long-term productivity of dairy calves. *J. Dairy Sci.* 95:783–793.
- Soberon, F., and M. E. Van Amburgh. 2013. Lactation Biology Symposium: The effect of nutrient intake from milk or milk replacer of preweaned dairy calves on lactation milk yield as adults: A meta-analysis of current data. *J. Anim. Sci.* 91:706–712.
- Staple, E., and S. Gurin. 1954. The incorporation of radioactive acetate into biliary cholesterol and cholic acid. *Biochim. Biophys. Acta* 15:372–376.
- Story, J. A. 1981. The role of dietary fiber in lipid metabolism. *Adv. Lipid Res.* 18:229–246.
- Suárez, B. J., C. G. Van Reenen, N. Stockhofe, J. Dijkstra, and W. J. J. Gerrits. 2007. Effect of roughage source and roughage to concentrate ratio on animal performance and rumen development in veal calves. *J. Dairy Sci.* 90:2390–2403.
- Terré, M., E. Pedrals, A. Dalmau, and A. Bach. 2013. What do preweaned and weaned calves need in the diet: A high fiber content or a forage source? *J. Dairy Sci.* 96:5217–5225.
- Thomas, D. B., and C. E. Hinks. 1982. The effect of changing the physical form of roughage on the performance of the early-weaned calf. *Anim. Prod.* 35:375–384.